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Previous research in the Lake Erie Watershed Management Study (LEWMS) points to the existence of economic incentives to reduce soil erosion on many row crop acres. One of the mechanisms for reducing soil erosion and ultimately phosphorus loadings in Lake Erie is the adoption of reduced tillage technologies on selected soils series.

The general purpose of this analysis is to rank geographic areas in the Lake Erie basin with respect to the apparant economic incentive for the adoption of

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reduced tillage technologies. At this point in time, the analysis investigates only "apparent" economic incentives. Reduced tillage technologies are used on a widespread basis; thus, analysis of the results of using these technologies are projections based on research results rather than actual farm experience.

PREFERRED AREAS FOR REDUCED TILLAGE TECHNICAL ASSISTANCE PROGRAMS IN THE UNITED STATES DRAINAGE TO LAKE ERIE

by

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July 1979

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INTRODUCTION

Previous research in the Lake Erie Wastewater Management Study (LEWMS) points to the existence of economic incentives to reduce soil erosion on many row crop acres. One of the mechanisms for reducing soil erosion and ultimately phosphorus loadings in Lake Erie is the adoption of reduced tillage technologies on selected soils series. It is estimated that erosion in the Basin could be cut nearly in half without a significant loss in net farm income through the adoption of reduced tillage practices on selected soils.

Given these apparent economic incentives for some farmers to decrease erosion, an educational and technical assistance program may speed up the adoption process of reduced tillage technologies and other conservation practices. If the assumption is made that adoption of technology is a function of economic incentives, educational and technical assistance programs should be located in those areas offering the greatest economic incentive to reduce erosion.

Certainly, society has reason to encourage the adoption of soil loss reducing technologies. Lake Erie Wastewater Management Study estimates that soil loss averages 3.1 tons per cropland acre over the Lake Erie Basin. Total soil loss in the Basin is estimated to be 26.9 million tons per year. As soil loss is delivered to streams, costs are incurred due to sediment, phosphorus, and other potential pollutants. In addition, future productivity is damaged when soils are excessively eroded, and it is estimated that over 30 percent of the Basin's cropland has soil loss which is detrimental to long run productivity.

The general purpose of this analysis is to rank geographic areas in the Lake Erie Basin with respect to the apparent economic incentive for the adoption of reduced tillage technologies. At this point in time, the analysis investigates only "apparent" economic incentives. Reduced tillage technologies

are not used on a widespread basis; thus, analysis of the results of using these technologies are projections based on research results rather than actual farm experience.

IMPACT OF TILLAGE SYSTEMS ON FARM INCOME

Previous analysis indicates wide differences in Basin net farm income when reduced tillage systems are adopted. These income differences are functions of soil and climatic characteristics in various geographic areas.

In order to estimate the impact of soil characteristics on net farm income under alternative tillage systems, the Basin's soil resources are analyzed. Each of the Basin's three hundred soil series are placed into one of five soil management groups, based on the likely yield response to changes from conventional tillage to minimum tillage and no tillage technologies. A brief description of these soil management groups is the following:

Tillage group 1 - Soils are moderately well, well, and excessively well drained. They have silt loam, loam, sandy loam, or loamy fine sand surface texture. They are low in organic matter. These soils' yields are at least as great with reduced tillage systems as with conventional tillage.

Tillage group 2 - These soils are somewhat poorly drained in their natural state. They have a silt loam, loam, sandy loam, or loamy fine sand surface texture. They are low in organic matter. Yields on these soils are at least as great with reduced tillage systems as with conventional tillage.

Tillage group 3 - They are somewhat poorly to very poorly drained. Tile does not provide adequate drainage. Surface texture is loam, silt loam, or silty clay loam. Most of these soils are low in organic matter. Yields are lower with reduced tillage technologies than conventional tillage.

Tillage group 4 - They are very poorly drained soils. They have surface textures of silty clay loam, clay loam, silty clay, or clay. They contain

relative high amounts of organic matter. Soils yield slightly less with reduced tillage technologies.

Tillage group 5 - These are organic soils, alluvial soils, and certain fine textured soils. Soils do not respond well to reduced tillage.

The response to reduced tillage systems also vary by climatic conditions. Generally, Ohio and Indiana are judged to have relatively favorable responses to reduced tillage systems, Michigan has a moderately favorable response, and Pennsylvania and New York have a relatively unfavorable response to reduced tillage systems. These differences in responses by state are primarily a function of temperature differences. Reduced tillage systems leave more organic matter on the soil surface. When reduced tillage is used on soils in cooler climates, they are slower to warm and to dry in the spring, and the soil's response to reduced tillage is impaired.

In addition to yield differences between reduced tillage and conventional tillage technologies, cost differences also exist. Generally, reduced tillage technologies save labor and energy and require lower capital investment than conventional tillage. However, chemical costs increase due to dependence on chemical weed control. Total operating costs and equipment costs for minimum tillage average about 8 percent less than conventional tillage costs. No tillage costs average about 10 percent less than conventional tillage costs.

Net farm income (gross returns less total operating costs and equipment costs) changes across the Basin as reduced tillage technologies are adopted. If either minimum tillage or no tillage technologies were used on soil management group 1 soils, net farm income on these soils is improved. Almost all soil management group 2 soils show improved incomes with the adoption incomes with the adoption of minimum tillage or no tillage. Only in the northeastern part of the Basin does reduced tillage on soil management group 2 soils result in

reduced incomes. If minimum or no tillage is used on soil management group 3 or group 5 soils, net farm income declines sharply over all the Basin. Finally, on soil management group 4 soils, net farm income remains about the same over most of the Basin with adoption of minimum tillage but declines in the northeastern part of the Basin. If no tillage is adopted on group 5 soils, net incomes decrease over all the Basin.

In summary, those tillage systems which generally give the highest net farm income on each soil management group are conventional tillage on soil management groups 3 and 5, minimum tillage on soil management group 4, and no tillage on soil management groups 1 and 2. This selective adoption of reduced tillage technologies is referred to as the "maximum reduction strategy". It provides for the greatest reduction in gross erosion (68.7 percent across the Basin) while increasing net farm income by an average of 6.9 percent.

ECONOMIC CRITERIA FOR BASIN SELECTION

The Lake Erie Wastewater Management Study is to select five sites for potential technical assistance-extension education programs. A host of criteria are to be used in their selection -- sediment yield, phosphorus yield, phosphorus bio-availability, erosion, size of site, existence of water quality monitoring, status of Section 208 planning, agency interest, and others -- as well as an economic criterion.

Four criteria are used to develop an economic ranking for counties in the Basin.

a. Which counties produce the largest change in net farm income per acre with the maximum reduction strategy? This criteria indicates those areas where farmers have the greatest economic incentive to reduce erosion.

b. Which counties produce the largest change in net farm income less

projected program costs? Some small counties may rank high according to the first criterion (net farm income per acre), but technical assistance-education program costs may make overall economic gains (net farm income minus program costs) relatively small.

c. Which counties produce the greatest reductions in annual soil loss per acre with the adoption of the maximum reduction strategy? While the precise relationship between pollution in Lake Erie and soil erosion is unknown, a causal relationship is well established. Thus, soil erosion costs Lake Erie water users. Excessive soil erosion also degrades future soil productivity. Again, the precise relationship between soil erosion and the loss of future productivity has not been determined, but costs of soil erosion to future soil users exist. This criteria indirectly considers the costs of soil erosion to downstream users and to future users of soil resources.

d. Which counties produce the greatest reductions in total annual soil loss with the adoption of the maximum reduction strategy? This criteria avoids high ranking for small counties based on their potential for reducing erosion. It rewards counties with large areas since a technical assistance-education program would have a greater likelihood of reducing total erosion in these counties.

A technical assistance-education program will be unable to implement a 100 percent adoption of preferred practices. For this analysis, it is assumed that the maximum reduction strategy is adopted on only 25 percent of the soils in each selected county.

RESULTS

The analysis reported in "Economic Impacts of Changing Tillage Practices in the Lake Erie Basin" is used to predict net farm income impacts of using

the maximum reduction strategy across the Basin. This analysis indicates average net returns are $36 per acre using conventional tillage with the existing crop enterprise mix.[1/] If the maximum reduction strategy would have a 25 percent adoption rate across the Basin, the Basin's farm income would increase by 1.5 percent.

Net farm income would increase in nearly every county with the adoption of the maximum reduction strategy (Table 1). Only in a few of the Basin's eastern counties would net farm income be adversely affected.

First, counties are ranked based on the change in net farm income per acre with adoption of the maximum reduction strategy. These changes are annual changes. To estimate all future benefits accruing to farmers rather than simply one year's benefit, it is necessary to use the present value of all future net farm income changes. These future benefits are estimated by discounting all annual net farm income changes by 12 percent.[2/] These estimated benefits per cropland acre are used to rank the counties, and the top fifteen counties are shown in Table 2 and their location in the Basin is illustrated in Figure 1.

Using this criterion, three general areas emerge as being important. One is northeastern Indiana-northwestern Ohio (Dekalb, Steuben, and Williams counties). The second is the southwest corner of the Basin (Allen and Auglaize) counties) and the third is the north central Ohio region (Crawford, Seneca, Wyandot and Hancock counties).

[1/] The analysis uses price assumptions developed by U.S.D.A. in 1976. Current net returns per acre would be higher than this due to higher crop prices.

[2/] Future net farm income change = $\frac{\text{Net farm income change}}{.12}$. The formula for computing present value is $PV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$ where PV is the present value, R_t is the net flow in year t, i is the discount rate, and n is the number of years over which the flows occur. When $n=\infty$ and R_t is constant the formula is equivalent to $PV=R_t/i$.

Table 1. Net Farm Income per Acre Under Existing Conditions and Under Maximum Reduced Strategy, by County

County	Annual Net Farm Income ($/acre)	
	Under Existing Conditions	After 100 % Adoption of Maximum Reduction Strategy
Monroe, MI	42.73	43.88
Crawford, OH	37.47	44.03
Seneca, OH	42.58	49.05
Huron, OH	27.96	32.13
Ottawa, OH	70.06	69.64
Sandusky, OH	56.81	58.12
Erie, OH	41.11	45.51
Wood, OH	68.64	70.01
Lucas, OH	49.54	50.18
Hancock, OH	51.60	57.02
Wyandot, OH	43.89	49.42
Hardin, OH	52.66	54.34
Marion, OH	43.92	45.90
Richland, OH	23.84	28.89
Henry, OH	69.19	71.54
Ashland, OH	17.78	22.58
Medina, OH	19.08	22.51
Cuyahoga, OH	8.24	8.24
Summit, OH	0	0
Lake, OH	16.36	21.07
Geanga, OH	9.38	10.94
Portage, OH	-	-
Stark, OH	-	-
Ashtabula, OH	-2.78	-0.86
Trumball, OH	-	-
Erie, PA	2.13	2.42
Crawford, PA	-4.74	-9.36
Chautaugua, NY	7.80	7.26
Erie, NY	12.83	13.93
Cattaraugus, NY	26.31	28.28

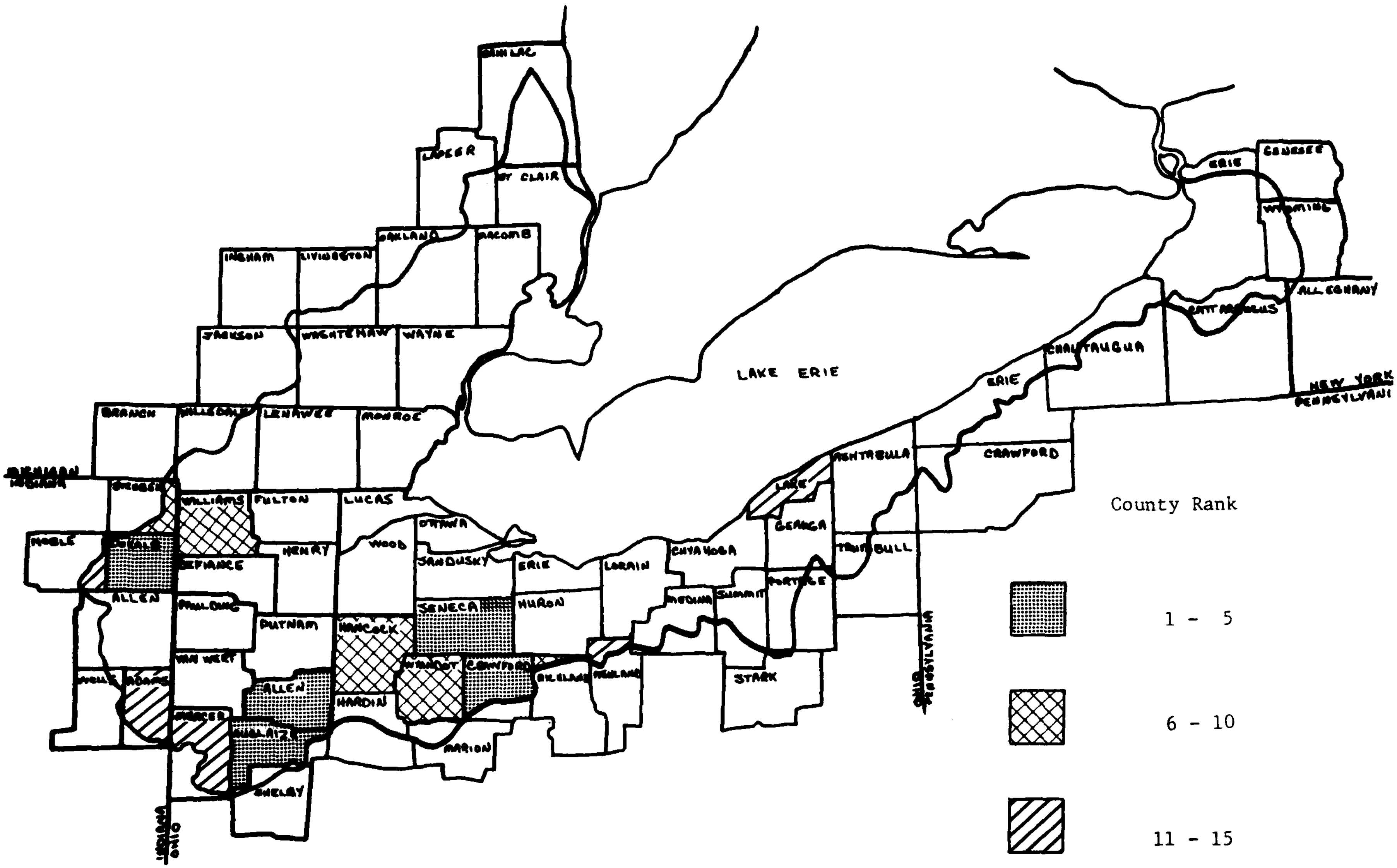
Table 1. (Cont'd)

Wyoming, NY	0.72	1.34
Sanilac, MI	24.13	24.35
Lapeer, MI	17.51	18.53
St. Clair, MI	25.04	25.79
Ingham, MI	0	0
Livingston, MI	12.02	13.28
Oakland, MI	20.60	21.63
McComb, MI	29.84	30.88
Jackson, MI	22.43	23.66
Washtenaw, MI	26.65	28.17
Wayne, MI	55.24	57.01
Hillsdale, MI	30.48	31.36
Lenawee, MI	43.22	44.60
Steuben, IN	31.48	37.06
Williams, OH	42.13	48.03
Fulton, OH	60.76	65.13
Noble, IN	38.28	43.14
Dekalb, IN	43.09	50.41
Defiance, OH	51.32	53.06
Lorain, OH	27.94	29.90
Allen, IN	52.71	57.08
Paulding, OH	44.47	45.05
Putnam, OH	58.11	59.74
Wells, IN	0	0
Adams, IN	53.02	58.06
VanWert, OH	60.46	63.54
Allen, OH	49.07	55.06
Mercer, OH	46.53	51.46
Auglaize, OH	44.79	50.70
Shelby, OH	-	-
Alleghany, NY	-	-

Table 2. Estimated Future Economic Benefits per Cropland Acre with a 25 Percent Adoption of the Maximum Reduction Strategy, by County

County	Rank	Future Economic Benefits to County's Farmers
		($ per cropland acre)
Dekalb, IN	1	$15.25
Crawford, OH	2	13.67
Seneca, OH	3	13.48
Allen, OH	4	12.48
Auglaize, OH	5	12.31
Williams, OH	6	12.29
Steuben, IN	7	11.62
Wyandot, OH	8	11.52
Hancock, OH	9	11.29
Richland, OH	10	10.52
Adams, IN	11	10.50
Mercer, OH	12	10.27
Noble, IN	13	10.12
Ashland, OH	14	10.00
Lake, OH	15	9.81

Figure 1. Change in Net Farm Income Per Acre with Twenty-five Percent Adoption of Maximum Reduction Strategy



The second criterion for ranking is the counties' change in net farm income less projected program cost. It is assumed that the technical assistance-education program would cost $300,000 in each county spread over a multiyear period. (This cost is assumed to be in present value terms.) Net "society" benefits for a county would be the present value of the total change in net farm income (income change per acre times cropland acres) less projected program costs. The top 15 counties are shown in Table 3 along with the net "society" benefit for each county. Figure 2 illustrates the location of these counties.

This ranking omits smaller counties having a high incentive to adopt reduced tillage practices. For example, Steuben, Noble and Adams counties in Indiana receive a low ranking. However, the three import general areas based on the first criteria are also important on the basis of this criteria. These general areas are northeastern Indiana-northwestern Ohio, the southwestern corner of the Basin and north central Ohio.

Lake Erie Wastewater Management Study staff estimates of gross erosion under existing conditions and under the maximum reduction strategy are used in the third and fourth criteria. Procedures for these computations are outlined in "Application of the Universal Soil Loss Equation in the Lake Erie Drainage Basin". Briefly, soil maps are used to inventory the Basins soils. Estimates of coefficients used in the Universal Soil Loss Equation (U.S.L.E.) are made for a large number of randomly selected points in the Basin. U.S.L.E. runs are made for a number of "management scenarios" including the maximum reduction strategy.

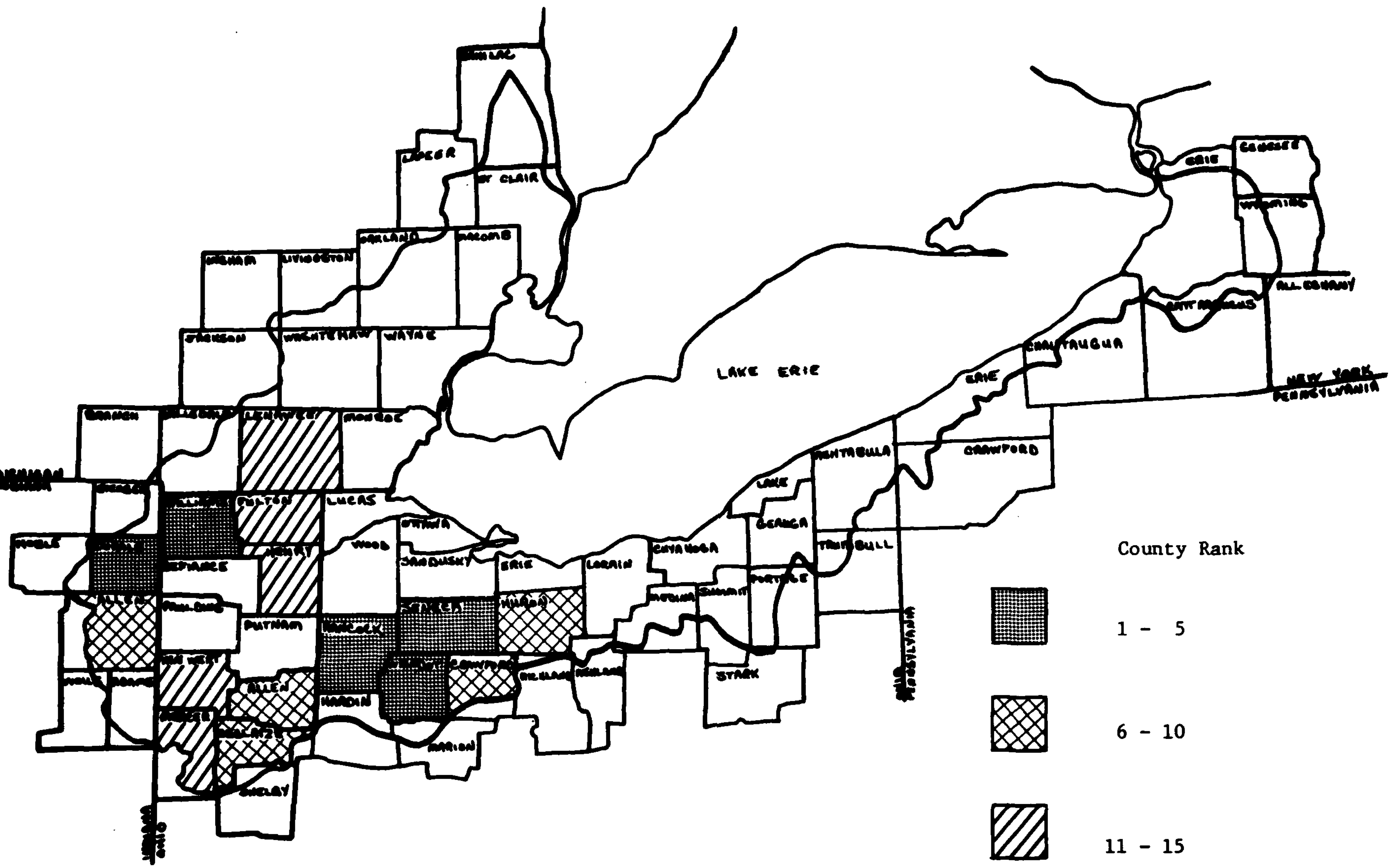
County rankings by the third criterion, change in soil loss per cropland acre, are different than rankings using the first two criteria. Northeastern Indiana counties (Noble, Dekalb, and Steuben) remain important as does the

Table 3. Estimated Net "Society" Benefits with a 25 Percent Adoption of the Maximum Reduction Strategy, by County

County	Rank	Net "Society" Benefits [a]
		(millions)
Seneca, OH	1	$3.61
Hancock, OH	2	2.90
Dekalb, IN	3	2.52
Wyandot, OH	4	2.31
Williams, OH	5	2.15
Allen, OH	6	2.04
Crawford, OH	7	1.91
Auglaize, OH	8	1.84
Huron, OH	9	1.70
Allen, IN	10	1.57
Fulton, OH	11	1.53
VanWert, OH	12	1.11
Mercer, OH	13	.92
Henry, OH	14	.78
Lenawee, MI	15	.69

[a] Net society benefits = $\frac{(\Delta NFI)(A)}{.12}$ - PC where ΔNFI is the annual change in net farm income per acre by a 25 percent adoption of the strategy, A is cropland acres, PC is program cost or $300,000.

Figure 2. Change in "Society" Income with Twenty Five Percent Adoption of Maximum Reduction Strategy



southwestern corner of the Basin (Allen, Auglaize, and Shelby counties). However, Lenawee county, Michigan appears as an important area, and north central Ohio counties (Seneca, Crawford, and Hancock counties) drop in the ranking. Figure 3 illustrates the top 15 counties according to this criteria.

The substantial reductions in average soil loss per acre can be seen in Table 4. With 100 percent adoption of the maximum reduction strategy, soil loss calculated from the Land Resource Information System data base declines by as much as 8.6 tons per acre in Noble county, Indiana. With a 25 percent adoption of the strategy, these soil loss reductions remain high.

When the fourth criterion, total soil loss reduction, is considered, Lenawee county, Michigan receives the highest ranking. A program in this county promises to be effective due to the relatively large reduction in soil loss per acre. In addition it has one of the largest cropland areas in the Basin. Other high ranking areas include northeastern Indiana-northwestern Ohio (Dekalb and Williams counties), the southwestern region of the Basin (Allen and Auglaize counties, Ohio), and north central Ohio (Wyandot, Seneca and Hancock counties). Table 5 and Figure 4 show the county rankings by this criterion.

SUMMARY

Each county's ranking under each of the four criteria are summed, and counties are ranked on the basis of this sum. Essentially, each of the four criteria are given equal weight under this procedure. Table 6 and Figure 5 shows the summary ranking along with the ranking under each of the four criteria for the top counties.

Dekalb, Indiana stands out as an appropriate county for a technical assistance-education program on the basis of this analysis. It consistently ranks at or near the top across all criteria. The next seven counties -- Allen (OH),

Figure 3. Change in Soil Loss Per Acre with Twenty Five Percent Adoption of Maximum Reduction Strategy

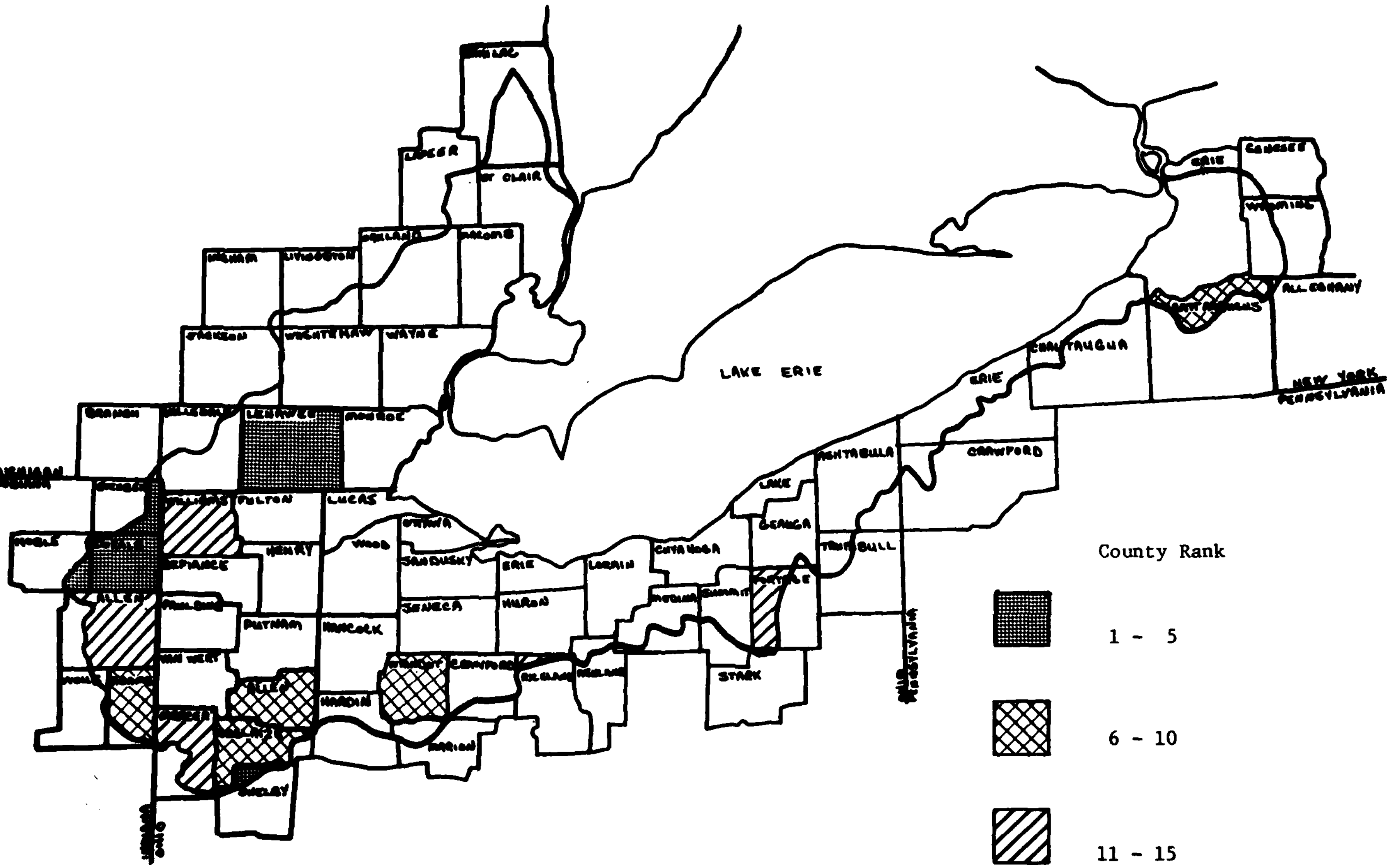


Table 4. Estimated Reduction in Per Acre Soil Loss With the Adoption of the Maximum Reduction Strategy, by County

County	Rank	Change in Soil Loss Per Cropland Acre: 100 Percent Adoption of Maximum Reduction Strategy	Change in Soil Loss Per Cropland Acre: 25 Percent Adoption of Maximum Reduction Strategy
		- tons per acre -	
Noble, IN	1	8.6	2.2
Dekalb, IN	2	6.9	1.7
Steuben, IN	3	5.9	1.5
Lenawee, MI	4	5.5	1.4
Shelby, OH	5	5.3	1.3
Adams, IN	6	4.9	1.2
Cattaraugus, NY	7	4.6	1.1
Allen, OH	8	4.6	1.1
Wyandot, OH	9	4.3	1.1
Auglaize, OH	10	4.2	1.1
Williams, OH	11	4.1	1.0
Portage, OH	12	3.9	1.0
Mercer, OH	13	3.5	0.9
Allen, IN	14	3.4	0.8
Richland, OH	15	3.3	0.8

Table 5. Change in County Annual Soil Loss with Adoption of Maximum Reduction Strategy

County	Rank	100 Percent Adoption of Maximum Reduction Strategy	25 Percent Adoption of Maximum Reduction Strategy
		- million tons -	
Lenawee, MI	1	1.88	.47
Dekalb, IN	2	1.27	.32
Wyandot, OH	3	.98	.25
Allen, OH	4	.86	.21
Williams, OH	5	.83	.21
Seneca, OH	6	.81	.20
Hancock, OH	7	.75	.19
Auglaize, OH	8	.73	.18
Allen, IN	9	.69	.17
Huron, OH	10	.56	.14
Crawford, OH	11	.54	.13
Washentaur, MI	12	.51	.13
Adams, IN	13	.43	.11
VanWert, OH	14	.43	.11
Fulton, OH	15	.42	.11

Figure 4. Change in County Annual Soil Loss with Twenty Five Percent Adoption of Maximum Reduction Strategy

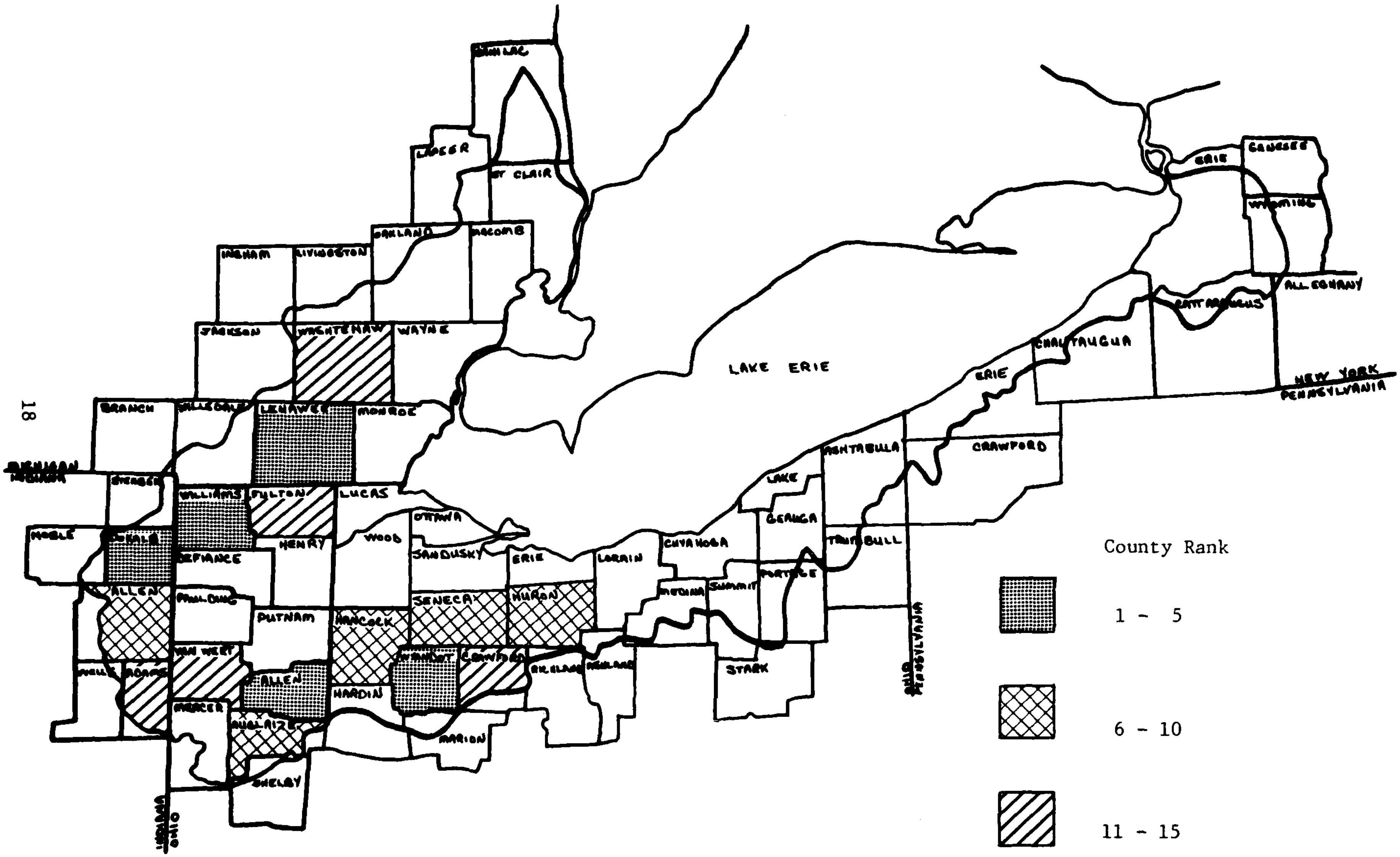
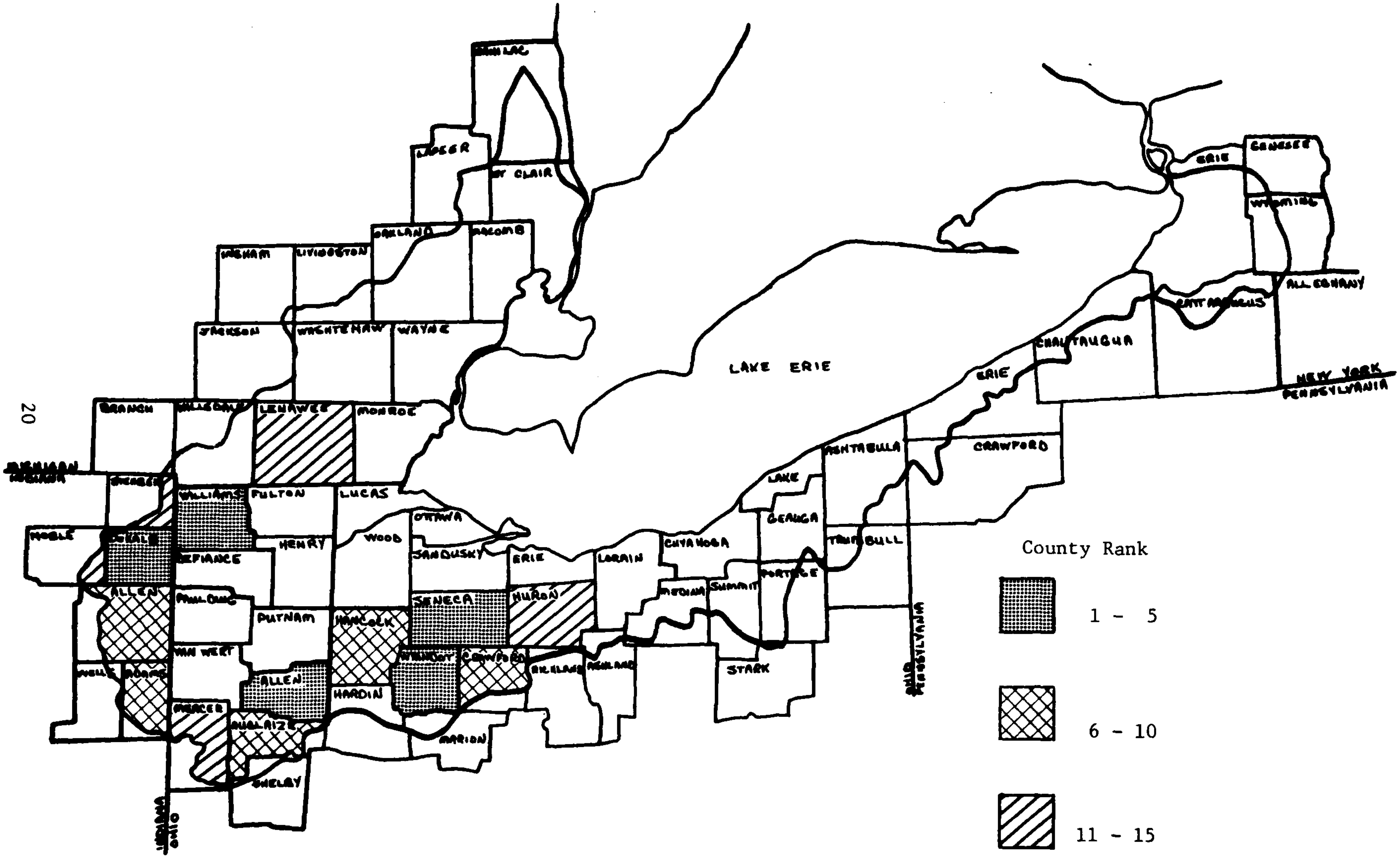


Table 6. Ranking of Top Fifteen Counties for Suitability of Technical Assistance-Education Program Using Economic Criteria

		Ranking for Each of the Four Economic Criteria			
County	Rank	Net Farm Income Per Acre	Society Income	Soil Loss Per Acre	Total Soil Loss
Dekalb, IN	1	1	3	2	2
Allen, OH	2	4	6	8	4
Wyandot, OH	3	8	4	9	3
Williams, OH	4	6	5	11	5
Seneca, OH	5	3	1	20	6
Auglaize, OH	6	5	8	10	8
Crawford, OH	7	2	7	16	11
Hancock, OH	8	9	2	22	7
Adams, IN	9	11	17	6	13
Allen, IN	10	17	10	14	9
Mercer, OH	11	12	13	13	16
Lenawee, MI	12	33	15	4	1
Huron, OH	13	19	9	24	10
Steuben, IN	14	7	30	3	24
Noble, IN	15	13	34	1	21

Figure 5. Summary Rankings for the Top Fifteen Counties Using Economic Criteria



Wyandot, Williams, Seneca, Auglaize, Crawford, and Hancock -- are relatively close in their summary ranking. Each has relatively high rankings on the basis of one or more of the four criteria and any of these would be reasonable choices for a technical assistance-education program.

A third group of counties include Adams, Allen (IN), Mercer, and Huron counties. These counties do not rank high under any of the criteria, and they would not be the preferred counties for a technical assistance-education program.

One county, Lenawee, receives a mediocre ranking but should be considered for the program. Lenawee ranks only twelfth on the basis of the summary ranking. However, it ranks very high in terms of potential soil loss reduction. The analysis indicated that Lenawee county farmers have only moderate incentives to increase net farm income by adopting reduced tillage practices. It is reasonable to conclude that the Lenawee county net farm income estimates for reduced tillage systems are biased downward. Reduced tillage yields for this southern Michigan county are probably better than Michigan averages. Thus, Lenawee county should be viewed as a reasonable choice for a technical assistance-education program.

No county in eastern Ohio, Pennsylvania, or New York appear in the summary ranking. If an area in the eastern part of the Basin is desired, Cattaraugus (NY) would be a likely county. Adoption of the maximum reduction strategy shows a large reduction in gross erosion (4.6 tons per acre under a 100 percent adoption rate) with slightly increased net farm income.